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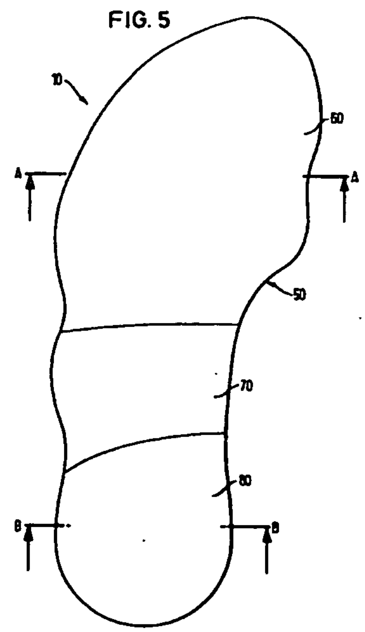
(54) **Shoe sole with improved dual energy management system**

(57) The present invention relates to sole unit for shoes, in particular sports shoes, comprising in horizontal direction at least two areas, wherein the first area (60) extends over the forefoot area and the second (80) over the rearfoot area, wherein the first area comprises an elastic material having an energy loss not exceeding 27%. According to a preferred embodiment, the second area additionally comprises a viscous material having an energy loss of at least 55%. According to yet another embodiment of the invention, the difference between the second and the first energy loss of the second and first areas (80 and 60) is at least 28%.

FIG. 5



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Description

1. Technical Field of the Invention

[0001] The present invention relates to a sole unit for shoes, in particular to a sole unit for sport shoes which provides a so-called "dual energy management system" to improve the biomechanical properties of the shoe.

2. Background of the Invention

[0002] During each footfall in walking, running and jumping, forces are acting between the ground and the foot. These forces are usually referred to as ground reaction forces (GRF). They can be quantified using appropriate measuring devices. The order of magnitude of GRF for walking is 1 to 1.5 times an athlete's body weight (BW). In running the forces are between 2 to 3 times BW and in jumping forces between 5 and 10 times BW have been measured.

[0003] The force-time pattern for each foot-ground interaction typically shows two distinct phases: a) An impact phase when the foot collides with the ground followed by b) a push-off phase when the athlete is propelled forward and upwards. Fig. 1a shows the landing motion of the foot in long distance running. About 80% of all runners contact the ground with the heel first. Fig. 1b shows the following push-off of mid- and forefoot. The corresponding vertical component of the GRF is shown in Fig. 1c. As can be seen, the curve consists of two distinct force maxima. The first maximum occurs after 20 to 40 milliseconds (ms) as a result of heel impact. In literature this force maximum is frequently called "impact force peak" because during this short time interval the human body can not react and adjust to it. The second force maximum occurs after 80 to 100 ms and is caused by the push-off action. This force is often called "active force peak" or "propulsive force peak".

[0004] The two types of forces have different consequences with respect to the human musculoskeletal system:

[0005] Impact forces do not contribute to athletic performance. Impact forces, however, have been associated in a number of studies with chronic and degenerative injuries in various sports, especially, when the heel is involved. The goal, therefore, is to reduce occurring impact forces under the heel using appropriate shoe sole constructions. The desired systems are the ones that deform easily under load and dissipate energy.

[0006] Magnitude and duration of active forces determine athletic performance, e.g. running speed, jumping height. This means, if an athlete wants to run at a certain speed, the appropriate level of active forces must be maintained. Thus, the intention is to enhance these forces. A show sole that minimizes energy dissipation as much as possible while at the same time provides the necessary cushioning can influence this.

[0007] Studies have shown that depending on the kind of sport, speed of running and an anatomical formation of the feet, etc., the relative height of the passive and active peak values can vary with respect to each other. In some cases, the situation shown in Fig. 1c can change in so far that the active peak value has the same height as the passive peak value or even higher. It is, however, typical that two peak values occur which are separated by about 60 milliseconds.

[0008] With respect to cushioning systems in the sporting goods industry, the following approaches were used in the prior art.

[0009] From the US A-5 695 850, for example, the concept is known to provide a sports shoe with a sole unit which is to improve the performance of the shoe. This is to be achieved by using components of the shoe or the sole which "regain" the energy during running and transform it during the push-off phase from the ground (i.e. in the area of the active peak value in Fig. 1c) into a forward movement. To this end, the use of elastical materials either in the complete sole area or limited to the forefoot area is described. As suitable elastical materials are among others 1, 4-polybutadiene/rubber compounds suggested or — as an inlay for the shoe — a mixture of EVA and natural rubber.

[0010] From the document DE 87 09 757 a sole unit is known which consists of a outsole and a midsole mounted thereon. The midsole is formed by a comparatively narrow frame-like extending strip defining a seat which is downwards closed by the outsole. Inside the seat two sole parts are provided, one of which extends from the forefoot part of the shoe to the beginning of the heel part where the second sole part is provided. The first sole part consists preferably of a plastic supporting inlay being comparatively yielding under pressure so that during walking with such a shoe a foot bed can be formed on the sole part providing a certain comfort. The sole part arranged in the heel area provides a shock absorber and consists of impact or shock absorbing material, for example silicon.

[0011] In the same way also the US-A -49 108 886 describes the use of shock absorbing inlays in the heel part of a sole unit. The US-A-4 316 335 discloses the use of a shock absorbing material not only in the forefoot part of a sole but also in the heel part, wherein, however, the damping properties are to be better in the heel part.

[0012] The EP 0 272 082, finally, describes the use of a spring plate in the forefoot area of a sole unit. The spring plate has the purpose to take up energy during each step and to release the energy during the push-off phase.

[0013] All of the above described known concepts, however, have the disadvantage that the suggested materials and material parameters for the heel or forefoot area are not adjusted or optimized for the time dependence of the above described passive and active peak values. Furthermore, the suggested materials are not coordinated with the other

material used in the sh e so that possible additional effects are not taken into account. Therefore, the intended effect is nly partly achieved and during running a "spongy" or "springy" feeling arises which considerably hinders the forward movement.

3. Summary of th Inv nti n

[0014] It is therefore the problem of the present invention to provide a well balanced sole unit in particular for sports shoes, where the passive and active force peak values arising during the natural cause of motion are optimally taken into account and the natural dynamics of the movement are optimally used.

[0015] Furthermore, it is an objective of the present invention to provide a sole unit at low costs having a long durability.

[0016] According to the present invention, this problem is solved by a sole unit in accordance with claims 1, 2, and 3, respectively.

[0017] In detail, the solution of the above problem is obtained by a sole unit for shoes, in particular sports shoes, consisting of at least one sole layer. This sole unit is according to the invention from front to rear (i.e. horizontal) direction divided into at least two different parts. The first horizontal part extends over the forefoot area and optionally also over the midfoot area of the sole unit, whereas the second horizontal part extends over the rearfoot area.

[0018] According to the teaching of claim 1, a material with predominately elastical properties is used in the first horizontal part comprising a (material specific) loss of energy not exceeding 27 %.

[0019] According to the teaching of claim 2, a material with predominately viscous properties is used in the second horizontal part having a (material specific) energy loss of at least 55 %.

[0020] Finally, according to the teaching of claim 3, an elastic material is used in the forefoot part having a first energy loss and a viscous material is used in the rearfoot part having a second energy loss, where the difference between the second energy loss and the first energy loss is at least 28 %.

[0021] In other words, the core of the present invention resides in the unique feature to provide in the forefoot area of the sole unit a layer of material having a predominately elastical damping characteristic. Such a material has in a forward movement the property that the pushing-off from the ground is supported by the "elastical back scattering " of the kinetic energy.

[0022] In the rearfoot area of the sole unit (the heel part), on the contrary, preferably a material layer is used comprising a predominately viscous damping characteristic.

[0023] The use of a viscous material leads to a "repulse-free" absorption of the arising impacts acting during running in particular on the heel of the foot, since the energy of the impact is transformed into heat.

[0024] The elastic and viscous materials used according to the invention are characterized by their material specific energy loss. The inventor of the invention has found that the critical material parameter for the provision of optimal materials for the rearfoot area and the forefoot area is the loss of energy which is to be determined experimentally. The energy loss is a parameter which is obtained from the response of a test material exposed to a force field.

[0025] To determine the response in a biomechanically adjusted manner, a procedure is used according to the invention where a sample of the material to be tested is subjected to a dynamical force field corresponding to the force field acting upon the feet during human running. Preferably, the GRF-force profile shown in Fig. 1c (separately for the forefoot and rearfoot area) acts upon the test material. A certain energy is by the GRF-force profile fed into the material leading to a deformation of the body of the material. This deformation is decomposed by the materials specific elastical properties having a certain time dependence and thereby leads to a recuperation of the energy. The energy recuperated in the this way is for physical reasons always less than the fed energy since a part of it is, dependent on the material, transformed into heat. If the recuperated energy is subtracted from the fed energy, a positive difference is obtained which can be designated as "loss of energy".

[0026] According to the invention it has been shown that elastic materials suitable for the forefoot area should have an energy loss not exceeding 27% to lead during the push-off phase of the foot to a measurable support of the upward and forward movement of the foot.

[0027] Furthermore, it has been shown that the viscous material used according to the invention for the shock absorbing in the rearfoot part must have an energy loss of at least 55 % to lead to a measurable reduction of the risk of injuries.

[0028] Finally, it has been shown according to the invention that by a combination of elastic and viscous materials in the forefoot and rearfoot area, respectively, which have a difference in energy loss of at least 28%, a combinational effect is obtained leading to an improved performance of the athlete, i.e. the running (or walking) takes place with a reduced energy consumption. This was experimentally determined by comparative studies of the oxygen consumption of athletes.

[0029] Preferably, the first horizontal area is the forefoot area and the second horizontal area is the rearfoot area of the sole unit. The first and the second horizontal areas of the sole unit are according to a preferred embodiment either in the same transversal layer (claim 4), or according to another preferred embodiment in two different transversal layers

(claim 5).

[0030] According to yet another preferred embodiment of the present invention, further layers are provided among the layer or the layers with the elastic and viscous areas. For exampl , an insole and an outsole may be provided. If such additional lay rs ar used, it is preferably necessary to tak a further material parameter into account, that is th dynamic stiffness of both the elastic and the viscous material in comparison to the dynamic stiffness of the material which forms the further layers of the sole unit. The dynamic stiffness is the gradient of the curve in a deformation force diagram in certain force intervals (between 1,000N- 1,500N and between 200N-400N).

[0031] To take the dynamic stiffness into account in embodiments where the sole unit consists of several layers is important, since the elastic properties in the forefoot area and the viscous properties in the rear foot area do not take effect, if the wrong materials are chosen. The situation is as in a series of two coupled springs. The effect of spring 1 with an especially adapted spring characteristic does not take effect, if the spring constant of the second spring is smaller than the spring constant of the first one. In this case the damping characteristic of the coupled springs is predominately determined by spring 2. Only after spring 2 has been (completely) compressed, spring 1 becomes effective.

[0032] For this reason, it is suggested in the preferred embodiments according to claims 7 and 8 to provide optionally present further layers of the sole unit with a dynamic stiffness which is equal to or exceeds the dynamic stiffness of the viscous and elastic materials. For the viscous materials, this is particularly relevant for forces between 200N and 400N.

[0033] The sole units in the preferred embodiments according to claims 9 to 11 are according to the invention preferably used in field sports (claim 9) in running shoes (claim 10), and in universal shoes (claim 11).

[0034] The elastic synthetic material used preferably in the forefoot area comprises 50 vol.-% ethylene vinyl acetate (EVA) and 50 vol.-% natural rubber (claim 13).

[0035] Finally, the viscous material which is according to the invention preferably used in the rear foot area, comprises a butyl-polymer (claim 14).

[0036] It has been found that these synthetic materials fulfill in particular the requirements to a sole unit according to the invention. They are therefore in particular suited as materials for the dual energy management system according to the invention.

4. Brief Description Of The Drawing

[0037] Further preferred embodiments of the present invention are discussed in the following with reference to the drawing which shows:

Fig. 1 The natural course of movement of a foot during running (Figs. 1a to b), and the resulting GRF-force profile (Fig. 1c);

Fig. 2a A force-time-diagram of two force fields which are exerted according to the invention from a measuring apparatus on the heel part and the forefoot part of sole units or material layers to determine the energy loss according to the invention and the dynamic stiffness;

Fig. 2b A measuring apparatus according to the invention as it is used for exerting the force profiles shown in Fig. 2a and the measurement of the resulting deformations (and thereby the energy loss and the dynamic stiffness);

Fig. 2c The force stamps used in the apparatus according to Fig. 2b for the heel part and the forefoot part;

Fig. 3 The deformation characteristic of a viscous material with the resulting energy loss (hatched) and the dynamic stiffness DS between 1 KN and 1.5 KN;

Fig. 4 The deformation characteristics of an elastic material with the resulting energy loss (hatched) and the dynamic stiffness DS between 1 KN and 1.5 KN;

Fig. 5 A sole unit according to a preferred embodiment of the invention where an elastic material is used in the forefoot area and a viscous material is used in the rearfoot area;

Fig. 6a A section along the line A-A (or B-B) of Fig. 5 showing a preferred embodiment of the sole unit according to the invention; and

Fig. 6b A section along the line A-A (or B-B) of Fig. 5 showing a further preferred embodiment of the sole unit according to the invention.

5. Detailed Description Of The Preferred Embodiments

[0038] In the following the currently preferred embodiments of the present inventi n are described with reference to the drawing.

[0039] Fig. 1 shows a human foot with a shoe 10 consisting essentially of a shaft 20 and a sole unit 50. As discussed in detail further below, the sole 50 consists preferably of a plurality of layers which are called layer ensemble in the following.

[0040] To illustrate the principles of the invention, firstly a foot and its natural course of motion during running is further discussed with reference to Fig. 1.

[0041] As shown in Fig. 1 and already mentioned in the introductory part, about 80% of the humans begin the course of motion of a step with the contact of the heel part of the foot to the ground. At this time, the human body is subjected to a heavy impact. In the subsequent phase of rolling-off, the affecting force decreases at first until it increases again during the moment of the pushing-off (cf. Fig. 1b).

[0042] The force-time diagram is therefore a curve with two maxima.

[0043] If for the confirmation of the above consideration a test person performs the typical course of motion during running on a force-time measurement platform, the force profile shown in Fig. 1c is obtained. Laid off as ordinate is the force equivalent (in multiples of the weight) and as abscissa the time in milliseconds. The diagram shown in Fig. 1c is also called GRF-diagram (since the forces exerting during a step on the foot — as mentioned in the introductory part — are also called "ground reaction forces" (GRF)).

[0044] As can be derived from Fig. 1c showing a typical example of a GRF-curve, the curve shows afier about 20 to 40 ms a first sharp maximum resulting from a rapidly increasing force which corresponds in the example shown in Fig. 1c to 2.5 times the weight. As already mentioned in the introductory part, this first peak value is also called "vertical force peak value" (VFIP-value). The phase shown in Fig. 1c as ranging from t = 0 to t = A (at approximately 30 ms to 50 ms) in the GRF-diagram is called the passive phase. It corresponds to the contact of the heel part of the foot with the ground (cf. Fig. 1a).

[0045] To the passive phase of the course of motion the so-called active phase follows in the exemplary GRF-diagram shown in Fig. 1c. The new increase of the force in the active phase is caused by the pushing-off of the foot from the ground (cf. Fig. 1b). The resulting impact on the human body is considerably smaller, since the increase of the force acts slower as in the passive phase (at about 80 to 100 milliseconds). The profile of the GRF diagram can vary significantly depending on the boundary conditions (running speed, anatomy of the foot, hardness of the ground, etc.).

[0046] Since the increase of the force in the passive phase is considerably faster than in the active phase, it leads to a higher stress on the heel, because the affecting impulse (impact of the force) is correspondingly higher. Furthermore, the impulse is during the contact with a hard surface "reflected" from the ground so that it has to be absorbed by the anatomy. This leads in particular in a long lasting stress (such as a marathon race) to considerable signs of injury or degeneration.

[0047] The stress on the forefoot part is in comparison thereto only for the reason of a smaller impact (a longer force increasing time) correspondingly smaller. Furthermore, the forefoot area comprises a larger area and an anatomy which allows a better body-internal damping.

[0048] For this reason, it was according to the invention deduced that the heel part needs in comparison to the forefoot part a better protection to avoid an anatomical injury. Since the forces increase more slowly in the forefoot area, the foot is better capable to adjust to the increase of force (which is smaller in this case).

[0049] Advantageous is, however, a property of the sole in the forefoot part which results in a reflection of the impact in running direction or away from the ground. For illustration, reference is made once more to Fig. 1b. If during the contact of the forefoot with the ground kinetic energy is transferred to the foot again, this leads to a pushing-off of the foot from the ground and thereby to a support of the forward movement.

[0050] The present invention is therefore based on the realization to provide in the heel part and in the forefoot part of a sole unit materials with different properties: In the forefoot part preferably an elastic material is used, whereas in the heel part preferably a viscous material is used.

[0051] However, there are no purely elastic or purely viscous materials in nature; there is always a combination of these two properties. Therefore, in the meaning of the present invention elastic and viscous materials are, to be exact, materials with elastic-viscous properties where one or the other property is more or less strongly developed.

[0052] A material is therefore according to the invention considered as being "elastic", if it is predominantly elastic, i.e. if it has only to a small extent viscous properties. On the other hand, a material is in the meaning of the present invention considered as being "viscous", if it has predominantly viscous properties, i.e. only to a small extent elastic properties.

[0053] Elastic means in this context that the materials elastically springs back under the influence of force fields or force impacts and ideally completely releases the energy taken up during the impact. Materials with viscous properties, on the other hand, are materials, which transform a large part of the received energy into heat, i.e. they deform only

insignificantly elastically.

[0054] If therefore a viscous material in the meaning f the invention is, as described above, preferably used in the heel part of a sole unit, it has the property to at least partly transform the impact transferred by the heel into heat and to avoid in this way that the impact is quasi "reflected" from the gr und and the heel is stressed. As a result, a very "soil" running feeling is subjectively felt by the runner.

[0055] The predominantly elastic material preferably used in the forefoot area has on the contrary the property to push-off the foot from the ground and to quasi "catapult the runner forward", since it quasi reflects the impact from the ground.

[0056] It follows from the above consideration that the energy loss arising during the deformation is in particularly suited to characterize or quantify viscous and elastic materials. This parameter (measured in %) describes the relation of the energy fed by the force field into the material to the energy regained by the springing back.

[0057] To determine the energy loss of suitable materials, an apparatus is used according to the invention which is shown in Fig. 2b. This apparatus consists of a platform (5) on which the material to be studied is arranged. This material can be present either in form of a single material layer (preferred) or — as shown — as a finished sports shoe. In any case, it is preferred that for the testing in accordance with the present invention the material sample is provided in the same thickness and preferably in the same shape as it is later on used in the respective shoes. The material to be studied is then by the aid of a stamp arrangement (7) by a (to be described further below) stamp 8 (cf. Fig. 2c) subjected to a defined force field. Below the platform (5), a (schematically drawn) measuring arrangement 6 is located to measure the resulting deformation of the test material (in millimeters). The setup of the stamping arrangement (7) and the measuring arrangement (6) is known to the person skilled in the art and does not have to be further described. A corresponding device is —except the respectively used stamps 8, cf. below- commercially available on the market under the trade name "INSTRON Testing Machine Testing Frame 8502 " from the company INSTRON Limited, High Wycombe, Great Britain.

[0058] The force field applied by the aid of the stamp 8 of the stamping arrangement 7 has according to the invention for the study of the elastic and viscous materials different profiles, to simulate the actual conditions as realistically as possible. Therefore, for the study of suitable viscous materials, a force field is used which is designated in Fig. 2a with the term "heel". To simulate as realistically as possible, further a stamp 8a is used having a geometry which is similar to the human heel. The stamp 8a has a circular cross section with a diameter of 5 cm (cf. Fig. 2c), and a cross sectional area at its bottom side (which is slightly curved) of 19,63 cm^2. For the measurements of suitable elastic materials, on the contrary, a force profile is used which is designated in Fig. 2a with the term "forefoot". The stamp 8b used in these measurements (cf. Fig. 2c) is adapted with its geometry to the human forefoot. Stamp 8b is of elongated shape having a length of 8,5 cm and a width of 5,0 cm. The cross sectional area at the bottom side (which is again slightly curved) is 42,50 cm^2. Finally, the investigated materials had a thickness as it is common in shoes (10 millimeters in the forefoot part; 20 millimeters in the rear foot part).

[0059] In the following, the experimental results obtained by the measurement apparatus 6,7 (cf. Fig. 2b) are discussed with reference to the Figs. 3 and 4.

[0060] Fig. 3 shows the deformation characteristic of a viscous material according to the invention, which is subjected by the apparatus shown in Fig. 2b to the force profile designated "heel" in Fig. 2a, where the deformation measured with the apparatus 6 is laid off as abscissa in dependence on the force field applied with the stamp 7. As can be derived from the Fig., the viscous material used preferably in the heel part shows a pronounced hysteresis behavior. During the increase of the force according to the force profile "heel" from Fig. 2a, a deformation appears which only slowly recedes with a substantially smaller counterforce on the stamp 8a. The resulting loss of energy can be graphically or numerically established and is represented by the hatched area in the diagram. As can be seen, a large part of the fed energy is transformed in heat in the viscous material according to the invention and is no longer available as restoring force when the material goes back into its original shape.

[0061] Apart from the loss of energy, a further parameter can be deduced from the graph in Fig. 3 which is essential for the present invention, i.e. the dynamic stiffness of the investigated material. The dynamic stiffness is defined as the relation between the exerted force F [N] and the resulting deflection d [mm]. Experiments have shown that for sports shoes in particular two ranges of the dynamic stiffness are of particular interest: The stiffness between 1000 N and 1500 N and the stiffness between 200 N and 400 N. These ranges have found to be of interest for sport shoes, depending on their field of use (cf. below) The dynamic stiffness between 1000N and 1500N is calculated as follows:

$$\text{Dynamic stiffness } DS_{1000\text{-}1500} = (F_{1500N} - F_{1000N}) / (d_{1500N} - d_{1000N}) \ [N/mm]$$

[0062] The value for the dynamic stiffness between 200 N and 400 N is correspondingly calculated; it is not shown graphically in Fig. 3.

[0063] The dynamic stiffness is according to the invention in sole units of interest which consist of an ensemble of layers (i.e. a plurality of layers of different mat rials). In such an arrangement (which can for example compris an inn r layer, an intermediate layer, the layer with the functional properties according to the invention —referred to in the following as "functional layers(s)"- and an outsole) the above described effect according to the invention is only obtained if the stiffness of the functional layer is not greater than the stiffness of the materials of which the other layers consist. As materials for the sole layers, in particular EVA (ethylene vinyl acetate) and PU (polyurethane) are used since they can be easily processed and have low cost. If the elasto-viscous properties of these materials are not to determine the overall properties of the sole, it is necessary that the dynamic stiffness of the viscous and elastic materials according to the invention is less than the dynamic stiffness of these materials.

[0064] Fig. 4 shows on the contrary the response of an elastic material according to the invention. As can be derived from Fig. 4, the elastic material shows only a very weak hysteresis behavior and therefore only a very small energy loss in the meaning of the invention. The material goes quasi immediately back into its original shape when the force decreases so that essentially the complete energy fed via the force stamp 8b is released. Here also the value of the dynamic stiffness between 1500N and 1000N is graphically presented (the corresponding value for the dynamic stiffness between 400N and 200N was left out once again for the sake of simplicity).

[0065] In the detailed study carried out in conjunction with the present invention, it was found that for obtaining the effect according to the invention certain values not only for the loss of energy in the elastic and viscous material but preferably also (in case of shoes with several layers of different materials) for the dynamic stiffness DS have to be achieved. These values, which are to be achieved according to the invention, are summarized in the table below:

Parameter	Elastic material	Viscous material
Energy loss (%)	< 27 %	> 55 %
Stiffness (200N — 400N)	< 300 N/mm	< 130 N/mm
Stiffness (1000N — 1500N)	< 600 N/mm or < 450 N/mm	< 250 N/mm or < 200 N/mm

[0066] As can be seen, the energy loss of the elastic material according to the invention should not exceed 27%. On the contrary, the energy loss in the viscous material according to the invention should be at least 55%. Comparative studies have confirmed that with a resulting minimal loss difference of 28% between the forefoot and the rearfoot, a considerable reduction of the risk of injuries in the range of the vertical force peak value is obtained and that on the other hand in the range of the active peak value the stored energy is optimally released again. The result is a shoe which is not only very comfortable to wear without the danger of injuries, but which also improves the performance of the athlete. Comparative studies with normal shoes have shown that athletes running a certain test distance with shoes in accordance with the present invention consumed less oxygen.

[0067] Concerning the values for the dynamic stiffness, the situation is more complex: Depending on the kind of sport, the situation is different since different kinds of sports lead to different requirements on the shoe. For example, it was found that in field sports (basketball, volleyball, soccer) the dynamic stiffness should be less than 600 N/mm between a 1000 N and 1500 N for the elastic material, and less than 250 N/mm for the viscous material.

[0068] In the case of running shoes, however, the dynamic stiffness of the elastic material should be less than 450 N/mm between 1000 N and 1500 N, and the dynamic stiffness of the viscous material should be less than 200 N/mm.

[0069] For a universal type shoe the following is a good compromise: The dynamic stiffness of the elastic material should be less than 600 N/mm between 1000 N and 1500 N, and less than 300 N/mm between 200 N and 400 N; the dynamic stiffness of the viscous material should be less than 250 N/mm between 1000 N and 1500 N and less than 130 N/mm between 200 N and 400 N.

[0070] In view of the above discussed requirements, it has been found that the - following materials are suitable for the present invention:

Table 1

Elastic material I.	
Parameter	**Material (VGB-1A)**
Loss of energy (%)	24.5%
Stiffness (200N — 400N)	230 N/mm
Stiffness (1000N — 1500N)	440 N/mm
Maximal deformation	61%
Durometer	52 Asker C
Specific weight	0.28 g/cm^3
Elasticity*	57%

*: Measured according to DIN 53512

[0071] The preferred material VGB-1A is a material with the following composition:

EVA (21%)	50 phr
Isoprene rubber:	50 phr
RB-500	6 phr
Stearic acid:	0.8 phr
T4:	1 phr
Zinc stearate:	1.2 phr
Zinc oxide:	2 phr
Dicumylperoxide:	0.6 phr
Blow promoters:	3.5 to 5.0 phr
Pigments:	X (depending on the color)

[0072] The term phr indicates an amount of additives (parts per hundred parts of rubber) which are added to a rubber for the "formulation" (cf. also Römpp Encyclopedia of Chemistry Version 1.3, Stuttgart/New York: Georg Thieme Verlag 1997).

[0073] This elastic material according to the invention, however, represents only the currently preferred embodiment. According to the invention, the fractions of EVA/rubber may be varied: It is also possible to use 50 to 70 vol.-% ethylenevinyl acetate (EVA) and 60 to 40 vol.-% natural rubber. This material has excellent elastic properties and can also be easily and with low cost formed into shoe soles using common forming procedures.

[0074] However, currently the best results are achieved, if the above described elastical material I. (VGB-1A) is used with the indicated coposition. It is explicitly mentioned, however, that the above given composition does not mean that other additives could not be added to the mixture (for example for influencing the color).

[0075] According to another preferred embodiment of the present invention, also another elastic material may be used as follows:

Table 2

Elastic material II.	
Parameter	**Material (VGB-7A)**
Loss of energy (%)	27 %
Stiffness (200N — 400N)	210 N/mm
Stiffness (1000N — 1500N)	480 N/mm
Maximal deformation	61%

Table 2 (continued)

Elastic material II.	
Parameter	Material (VGB-7A)
Durometer	52 Asker C
Specific weight	0.28 g/cm^3
Elasticity	55%

[0076] The material VGB-7A is a material with the following composition of the main ingredients:

EVA 462	60 phr
IR (rubber) 2200	30 phr
Engage 003	10 phr
RB-500	6 phr

[0077] According to the present invention, the following materials are particularly useful as viscous materials:

Table 3

Viscous material I.	
Parameter	Material (B-HD45)
Loss of energy (%)	65%
Stiffness (200 N — 400 N)	120 N/mm
Stiffness (1000 N — 1500 N)	200 N/mm
Maximal deformation	60%
Durometer	45 Asker C
Specific weight	0.42 G/cm^3
Elasticity	10%

[0078] The material B-HD45 is a material with the following composition:

Butyl-polymer:	100 phr
Filling material:	30 phr
Activator:	1 phr
Dicumylperoxide:	4 phr
Antioxidant:	1 phr
Polymeric plastifier:	3 phr
Blow promoter:	4 phr

[0079] B-HD45 is provided as sheet-stock material, and is subsequently processed to form the desired sole layer.

[0080] Alternatively, as another viscous material, the following material may be used including Butyl-Polymer and Norsorex (a kind of rubber) as main ingrediants.

Table 4

Viscous material II.	
Parameter	Material (BIM-50)
Loss of energy (%)	65%
Stiffness (200 N — 400 N)	120 N/mm

Table 4 (continued)

Viscous material II.	
Parameter	Material (BIM-50)
Stiffness (1000 N — 1500 N)	200 N/mm
Maximal deformation	60%
Durometer	50 Asker C
Specific weight	0.42 G/cm^3
Elasticity	10%

[0081] The material BIM-50 corresponds, as far as its composition is concerned, to the above described material B-HD 45. The difference is, however, that BIM-50 is compression molded, to form the sole layer.

[0082] In comparison to the elastic and viscous materials in accordance with the present invention; the relevant parameters in view of the invention of known EVA are given in the following tables. The first table shows the data of typical EVA being processed for the forefoot part of a sole structure, whereas the second table (table 6) reflects the date of typical EVA being processed for use in the rearfoot part of a sole structure:

Table 5

Comparison table for EVA (forefoot)	
Parameter	Material (EVA)
Energy loss (%)	33+/- 2 %
Stiffness (200 N — 400 N)	260+/- 20 N/mm
Stiffness (1000 N — 1500 N)	520+/- 20 N/mm

Table 6

Comparison table for EVA (rearfoot)	
Parameter	Material (EVA)
Energy loss (%)	38+/- 2 %
Stiffness (200 N — 400 N)	120+/- 20 N/mm
Stiffness (1000 N — 1500 N)	220+/- 20 N/mm

[0083] Figs. 5 and 6 show a preferred embodiment of a sole unit according to the invention taking the materials discussed in detail above into account.

[0084] Fig. 5 shows a sole according to the invention in horizontal cross-section. Presented is the outsole 50 of the shoe 10 which is divided into a forefoot area 60 and a rearfoot area 80. The sole 50 itself can consist of a plurality of single layers, as this is common place in sports shoes. For example, the sole can consist of an outsole 55, a midsole 59 and a not shown insole (cf. Fig. 6a).

[0085] In a preferred embodiment, the functional layer 57 according to the invention is arranged between the outsole 55 and the midsole 59. The functional layer 57 can be divided into two horizontal parts: The forefoot part 60 consisting f the according to the invention predominant elastic material and the heel part 80 consisting of the predominantly viscous material. Between these two horizontal parts a further transition area 70 can be provided. This, however, is not imperative; the forefoot area 60 and the rear foot area 80 may also contact each other directly.

[0086] According to an alternative embodiment of the present invention (not shown), also two functional layers 57 can be provided. In this case, the first functional layer comprises in the forefoot area the elastic material according to the invention and the second functional layer comprises in th heel part th viscous material according to the invention.

[0087] As can be derived from Fig.s 6a and 6b, the functional layer 57 according to th invention extends in two preferred embodiments slightly (Fig. 6a), or to a large extent over the midsole 59. This depends on the use of the sports shoe. In cases where the probability of a sideways contact of the foot and the ground is high (in all sports where leaps are taking place), the embodiment according to Fig. 6b is preferred. On the contrary, in running shoes, for example, the embodiment according to Fig. 6a is preferably used.

[0088] With respect t the preferably used materials according to the present invention, not only elastical but also viscous materials per se are known in the prior art in principle. The used materials, however, should preferably have special properties to qualify as a sole material for sport shoes In accordance with the present invention, the materials in accordance with the present invention should be easy to form with common procedures, have a low weight and a high wear and tear resistance. For this reason, many of the known materials (for example natural rubber as elastic material) cannot be considered.

[0089] It is particularly set forth that the scope of the present invention is not restricted to the above discussed preferred embodiments. Particularly, all obvious alterations of features are deemed to be also covered. For example, in the above description of the preferred embodiments of the present invention, it has been suggested that for the variation of the preferably used stiffness of the various sole layers, particular material compositions are preferably used. The same result may be also obtained if the thickness of the sole layer or parts thereof is appropriately adjusted. Furthermore, the materials in accordance with the present invention need not to form a complete forefoot or rearfoot part of the sole. Alternatively, smaller pieces thereof may be implemented in the respective sole parts.

Claims

1. Sole unit for shoes, in particular sports shoes, comprising in horizontal direction at least two areas, where the first area (60) extends over the forefoot area and the second (80) over the rearfoot area, where the first area comprises an elastic material having an energy loss not exceeding 27%.

2. Sole unit for shoes, in particular sports shoes comprising in horizontal direction at least two areas, where the first area (60) extends over the forefoot area and the second (80) over the rearfoot area, where the second area comprises a viscous material having an energy loss of at least 55%.

3. Sole unit for shoes, in particular sports shoes comprising in horizontal direction at least two areas, where the first area (60) extends over the forefoot area, and the second (80) over the rearfoot area, where the first area (60) comprises an elastic material having a first energy loss and the second area (80) comprises a viscous material having a second energy loss, where the difference between the second and the first energy loss is at least 28%.

4. Sole unit according to one of the preceding claims, wherein the first (60) and the second (80) horizontal areas are arranged in a single layer (57) of the sole unit (50).

5. Sole unit according to one of the preceding claims 1 to 3, where the first (60) and the second (80) horizontal areas are arranged in two different layers (57) of the sole unit (50).

6. Sole unit according to one of the preceding claims 4 or 5 comprising, among the layer or the layers (57) with the elastic material and the viscous material at least one additional layer, in particular an outsole layer (55) and/or an insole layer (59).

7. Sole unit according to claim 6, wherein the additional layer or the additional layers (55, 59) have a dynamic stiffness, and wherein the dynamic stiffness of the elastic material is equal to or smaller than the dynamic stiffness of the other layer or layers (55, 59).

8. Sole unit according to claim 6, wherein the additional layer or the additional layers (55, 59) have a dynamic stiffness, and wherein the dynamic stiffness of the viscous material between 200N and 400N is equal to or smaller than the dynamic stiffness of the other layer or layers (55, 59).

9. Sole unit according to one of the preceding claims 1 to 6, wherein the dynamic stiffness of the elastic material is less than 600 N/mm between 1000 N and 1500 N and the dynamic stiffness of the viscous material less than 250 N/mm.

10. Sole unit according to one of the preceding claims 1 to 6 wherein the dynamic stiffness of the elastic material is less than 450 N/mm between 1000 N and 1500 N and the dynamic stiffness of the viscous material is less than 200

N/mm.

11. Sole unit according to ne of the preceding claims 1 to 6 wherein the dynamic stiffness of the elastic material is less than 600 N/mm between 1000 N and 1500 N, and wherein the dynamic stiffness of the viscous material is less than 250 N/mm between 1000 N and 1500 N and less than 130 N/mm between 200 N and 400 N.

12. Sole unit according to one of the preceding claims, wherein the elastic material comprises

    a. 50 to 70 vol.-% ethylene vinyl acetate (EVA), and
    b. 50 to 30 vol.-% natural rubber.

13. Sole unit according to one of the preceding claims 1 to 11, wherein the elastic material comprises 50 vol.-% ethylene vinyl acetate (EVA), and 50 vol.-% natural rubber.

14. Sole unit according to one of the preceding claims wherein the viscous material comprises a butyl polymer and norsorex.

15. Sole unit according to one of the claims 1 to 14, wherein the viscous material comprises 100 phr of a butyl-polymer, 30 phr of a filling-material, 1 phr of an activator, 4 phr of a dicumylperoxides, 1 phr of an antioxidant, 3 phr of a polymer-plastifier and 4 phr of a blow promoter.

FIG. 1

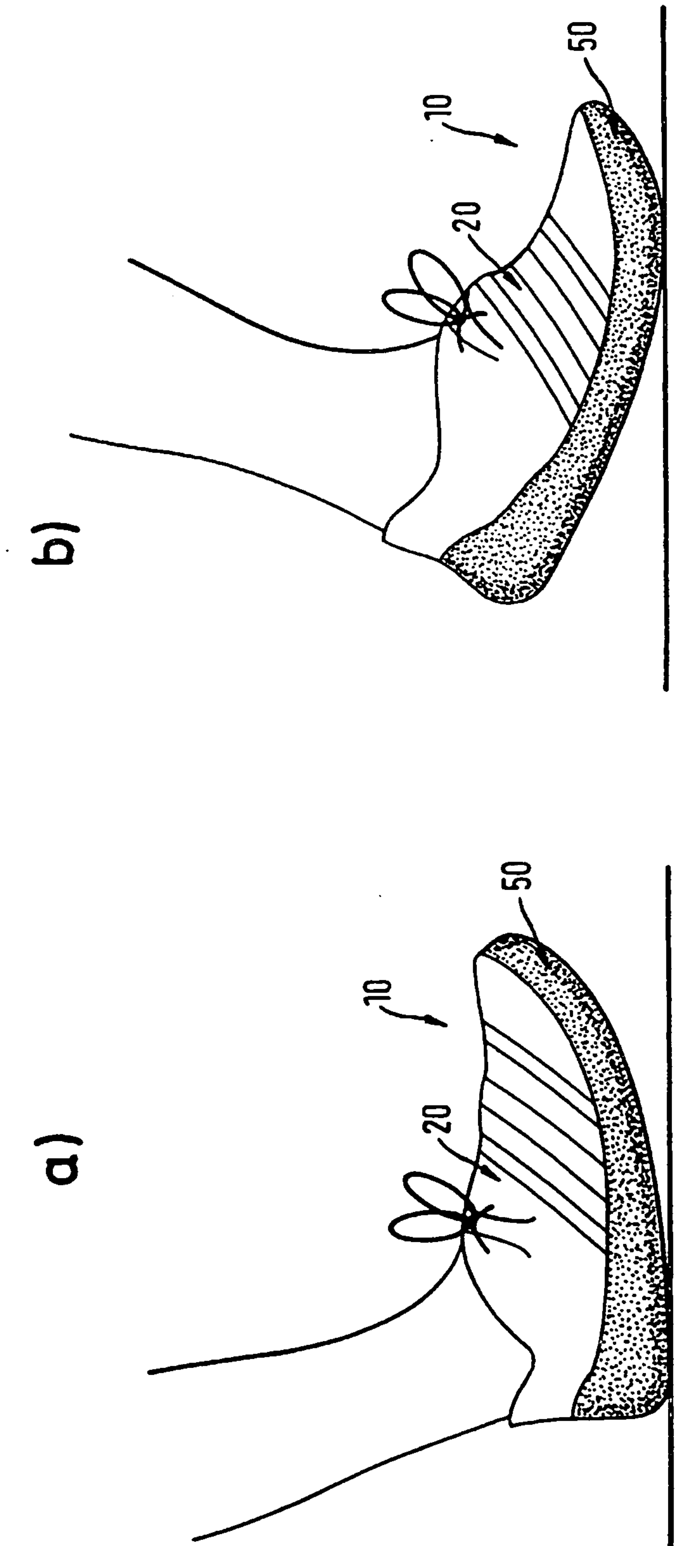


FIG. 1

c)

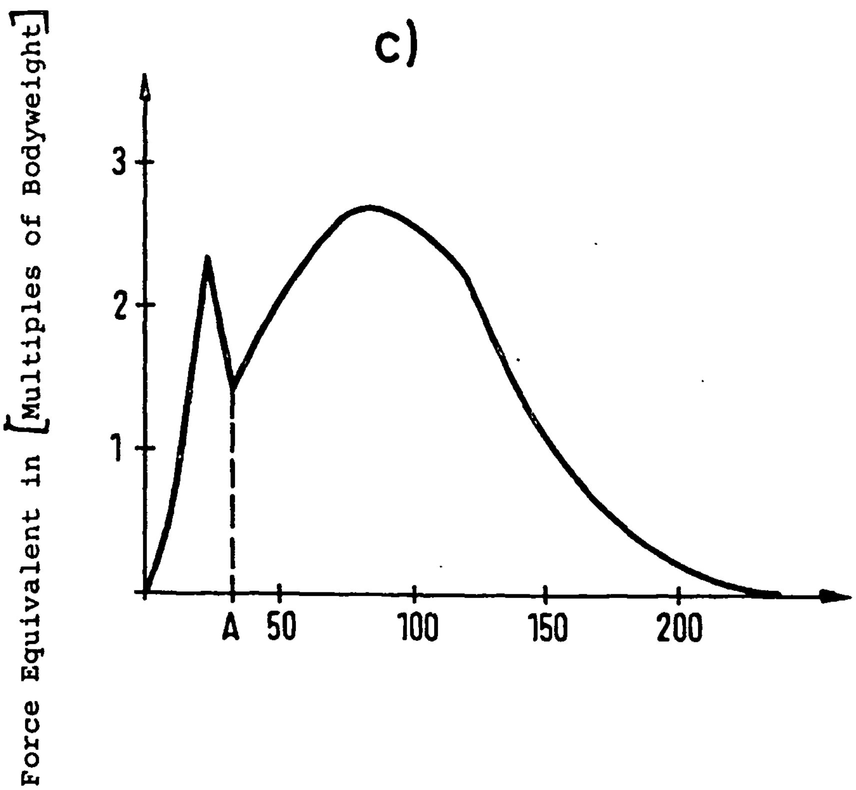

Force Equivalent in [Multiples of Bodyweight]
3
2
1
A
50
100
150
200

FIG. 2

a)

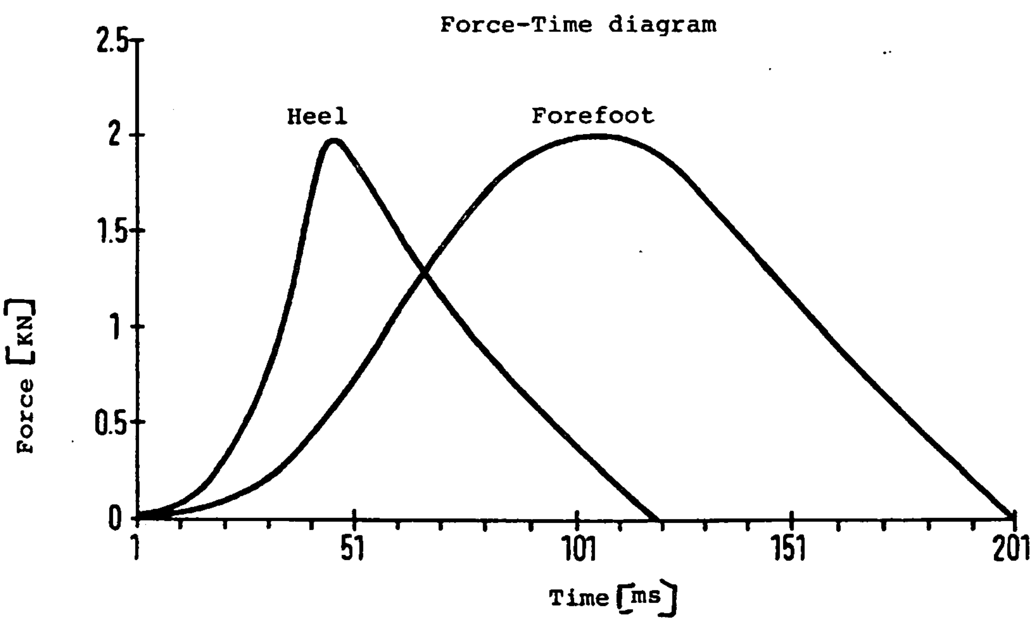
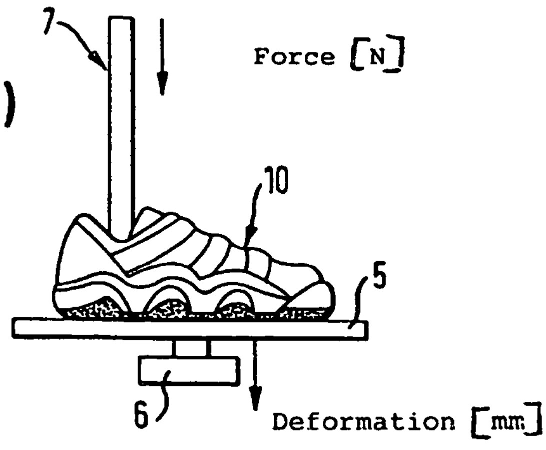

Force-Time diagram
Heel
Forefoot
2.5
2
1.5
1
0.5
0
Force [KN]
1
51
101
151
201
Time [ms]

FIG. 2

b)


7
Force [N]
10
5
6
Deformation [mm]

c)

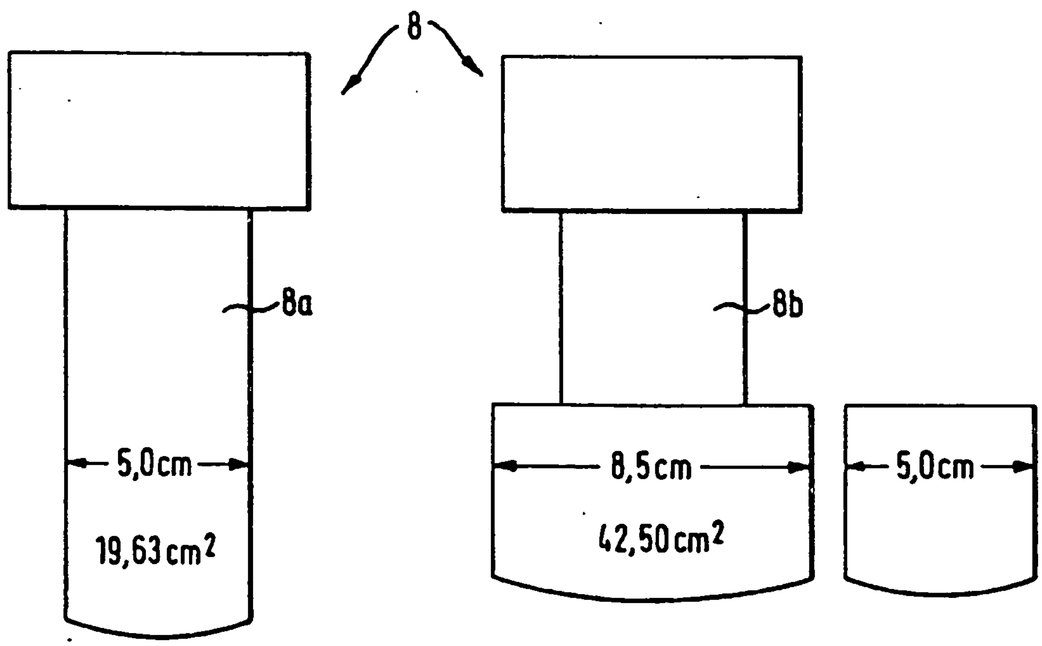

8
8a
5,0cm
19,63cm²
8b
8,5cm
42,50cm²
5,0cm

FIG. 3

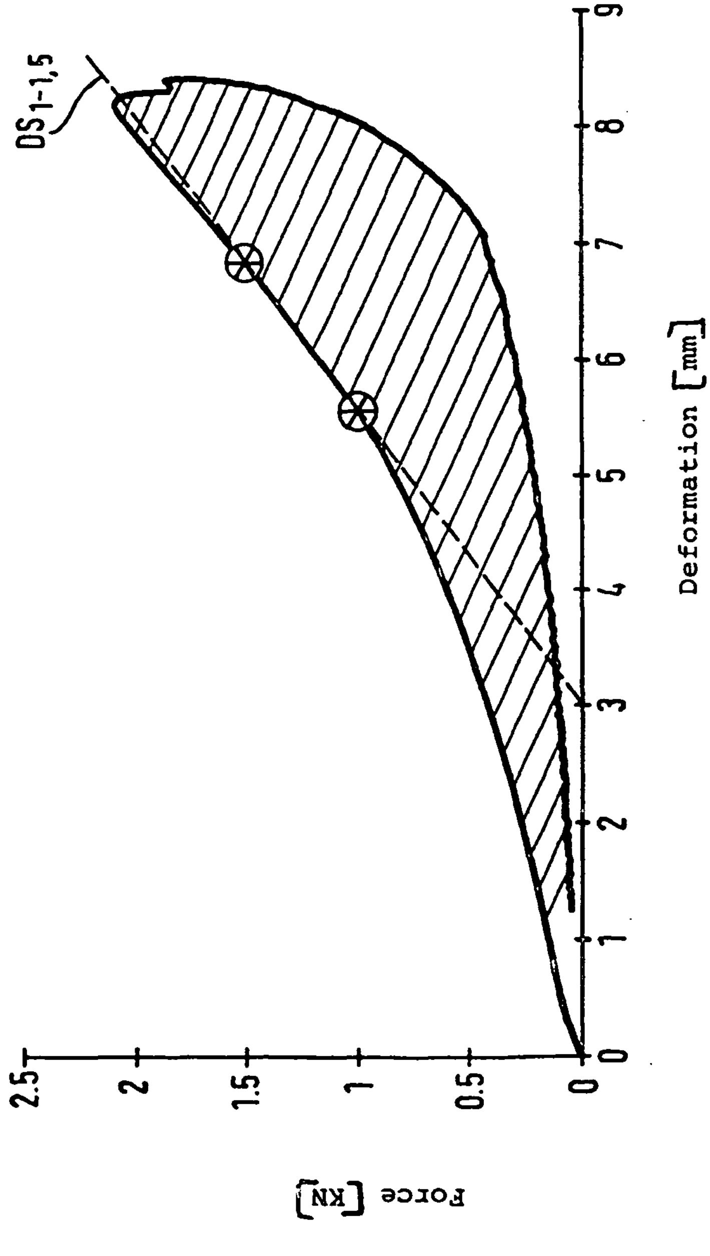


FIG. 4

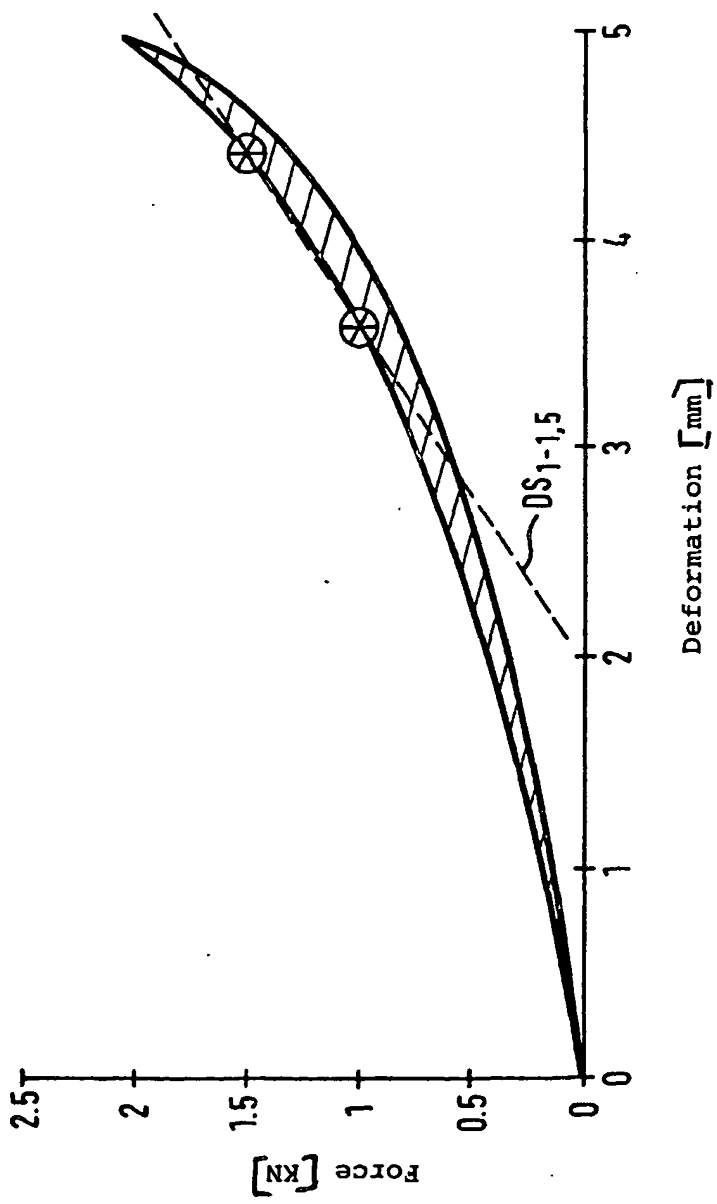


FIG. 5

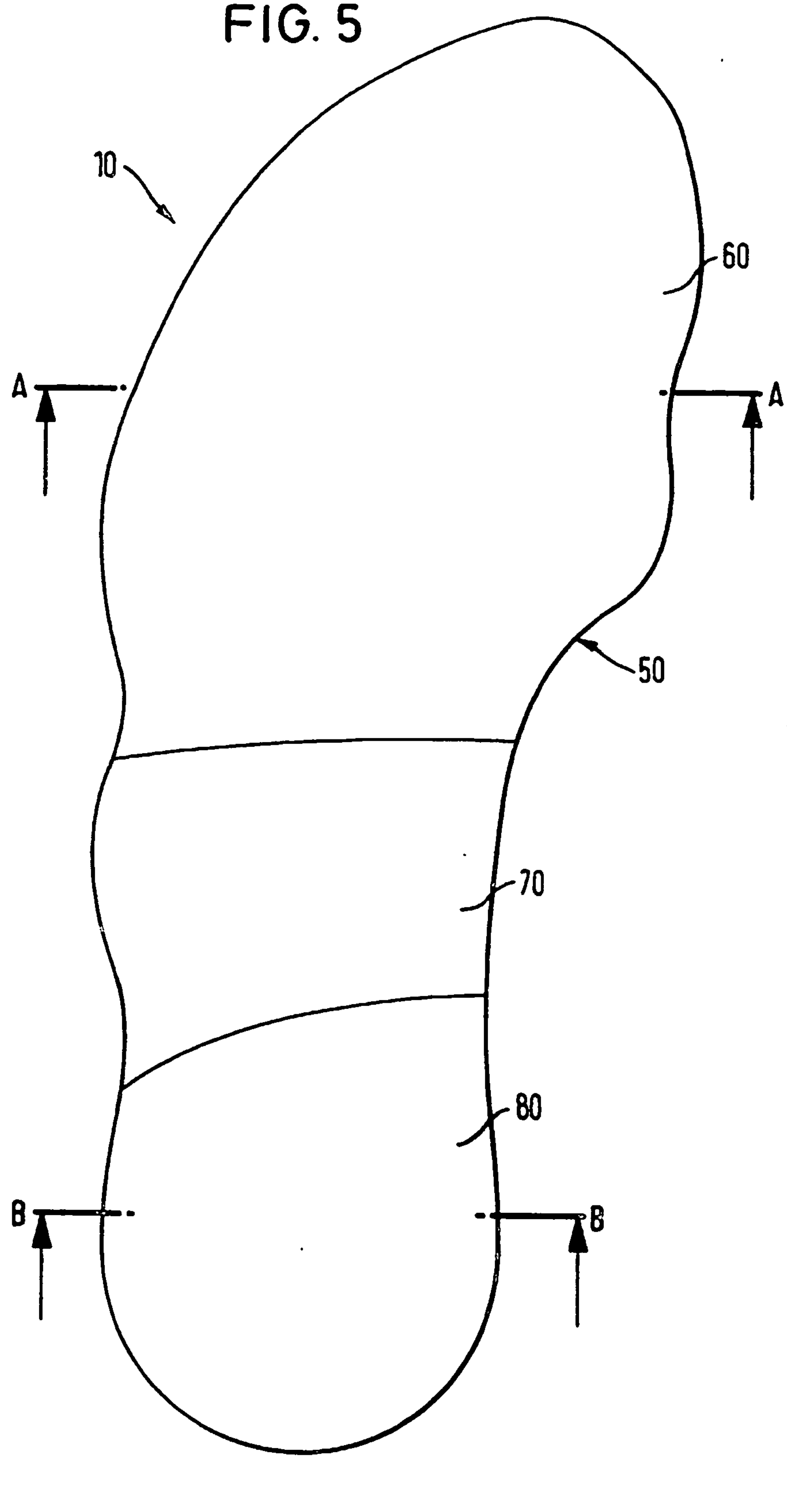
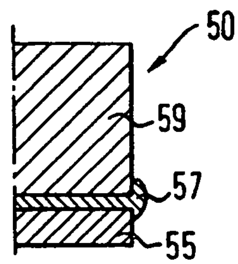
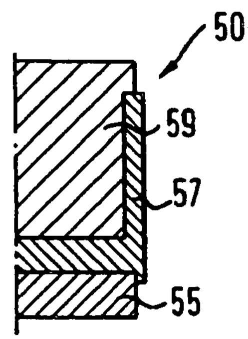


FIG. 6

a)



b)



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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 6110

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	US 4 316 335 A (E. GIESE) 23 February 1982 (1982-02-23) * the whole document *	1-3	A43B13/18 A43B13/16
A,D	EP 0 272 082 A (THE REGENTS OF THE UNIVERSITY OF MICHIGAN) 22 June 1988 (1988-06-22) * the whole document *	1-3	
A,D	US 5 695 850 A (W. CROW) 9 December 1997 (1997-12-09) * the whole document *	1-3	
A	DE 87 09 757 U (SALAMANDER) 24 September 1987 (1987-09-24) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A43B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 July 1999	DECLERCK, J

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19-07-1999

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4316335 A	23-02-1982	NONE	
EP 0272082 A	22-06-1988	AT 79229 T	15-08-1992
		AU 601005 B	30-08-1990
		AU 8250087 A	16-06-1988
		CA 1330485 A	05-07-1994
		DE 3781121 A	17-09-1992
		GR 3005540 T	07-06-1993
		JP 1085601 A	30-03-1989
		JP 1970819 C	18-09-1995
		JP 6098050 B	07-12-1994
		US 5315769 A	31-05-1994
		US 5052130 A	01-10-1991
		US 5191727 A	09-03-1993
US 5695850 A	09-12-1997	US 5554694 A	10-09-1996
		CA 2200152 A	15-09-1996
DE 8709757 U	24-09-1987	NONE	

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